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(19)



(54) RESISTANCE WELDING ELECTRODE AND METHOD OF  
 MAKING SAME

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 ica, do hereby declare the invention for  
 which we pray that a patent may be granted  
 to us and the method by which it is to be  
 performed to be particularly described in  
 and by the following statement:-

The present invention relates to resist-  
 ance welding and, more particularly, to an  
 improved electrode for use in a resistance  
 welding device.

Resistance welding has long been used as  
 a quick and effective method of joining  
 metal members. The workpieces to be  
 welded are placed in an abutting relation-  
 ship and a large current is caused to flow  
 across the boundary between the members  
 by a pair of opposed electrodes. The current  
 causes the surfaces of the workpieces to be  
 heated sufficiently to cause the formation of  
 a weld nugget. Typically, the electrodes  
 apply significant pressure to the workpiece  
 during welding. This facilitates the welding  
 process by urging the material together and,  
 also, reducing electrical resistance between  
 the electrode tip and the workpiece material.

Since the welding is accomplished by  
 resistance heating of the material being  
 welded, it will be appreciated that the  
 electrodes will also be heated substantially.  
 It is important to have an electrode of high  
 electrical conductivity in order to minimize  
 the power loss in the electrode and the  
 resulting heating of the electrode. It is also  
 important to have an electrode which is  
 capable of withstanding significant distort-  
 ing force at the elevated temperatures which  
 result from the welding process. Hollow  
 electrodes have long been used for resist-  
 ance welding with cooling fluid supplied to  
 the interior cavity in order to reduce sub-

stantially the temperature of the electrode  
 shank. It will be appreciated, however, that  
 this method of cooling has certain limita-  
 tions and, further, that the electrode tip  
 cannot be cooled effectively in this manner.

Electrodes have, in the past, been formed  
 of high conductivity copper in order to  
 minimize the power loss in the electrodes.  
 Such electrode material has a relatively  
 limited life, however, which is due in large  
 part to deformation of the electrode tip after  
 repeated welding operations at high temper-  
 ature and pressure. It has been the usual  
 practice to reshape or redress the electrode  
 tips to the desired shape. This can be  
 accomplished only a limited number of  
 times, however, and eventually the elec-  
 trode must be discarded. Not only is it  
 expensive to discard such electrodes, but the  
 down time of the welding machine for  
 replacement of redressed electrodes may be  
 even more expensive.

In order to minimize the cost of scrapping  
 copper electrodes, two piece electrodes  
 having a replaceable electrode tip and a  
 reusable shank have been used. U.S. Pa-  
 tents Nos. 2,440,463, 2,780,718, 2,829,239,  
 and 2,402,646, all show replaceable elec-  
 trode tips which are frictionally engaged by  
 a shank portion of the electrode. U.S.  
 Patents Nos. 2,437,740, and 2,472,173,  
 show mechanical brackets or set screw  
 arrangements for holding the replaceable  
 welding electrode tip.

Such a replaceable tip may also be  
 attached to the shank portion by threading  
 engagement as shown in U.S. Patents Nos.  
 2,761,973, 2,796,514, and 3,310,087. Both  
 U.S. Patents Nos. 2,257,566, and 2,411,859,  
 show welding electrode tips or tip portions  
 which are mechanically interlocked with a  
 shank portion. In the latter device, a rein-  
 forcing cap of hardened metal surrounds but  
 does not cover the electrode tip. In the  
 electrode of 2,257,566 a replaceable tip is

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pressed into interlocking engagement with the shank portion.

In U.S. Patent No. 3,446,932, a replaceable tip for a spot welding electrode is disclosed which is formed from a hardened material, e.g., a drawn copper slug. The tip is then bonded to the electrode body by fusible material, such as solder, which has a fusion point lower than the annealing temperature of the tip. U.S. Patent No. 2,138,388 discloses a replaceable electrode tip which is welded to the shank. U.S. Patent No. 2,795,688 discloses a welding electrode having a stainless steel alloy tip which is brazed onto a shank made of copper.

U.S. Patent No. 3,909,581 discloses a composite resistance welding electrode having a holder made of an inexpensive, relatively soft metal with high electrical and thermal conductivity and a tip which has additional strength at resistance welding temperatures. The tip may be formed of a more costly material, such as various copper alloys. The tip may be connected to the shank portion with a pressure fit or, alternatively, by brazing. A pressure fit will generally be unacceptable due to the high electrical resistance at the joint. If the tip is brazed onto the shank, however, the shank may be somewhat annealed and weakened. Thus, the improved number of welding operations which could be expected from such an electrode are reduced.

One material which has recently been developed and which has shown high promise for use in resistance welding electrodes is a dispersion strengthened copper which is formed by internal oxidation of a dilute copper-aluminum alloy. This material is extremely hard at welding temperatures and highly conductive. U.S. Patents Nos. 3,779,714, 3,884,676 and 3,893,841, disclose dispersion strengthened metals of the type intended to be used with the present invention. As discussed in the August 1976 edition of METALS ENGINEERING QUARTERLY, pages 10-15, this dispersion strengthened copper alloy material produces superior welding electrodes. The disadvantage of such an electrode, however, is the relatively high cost; this dispersion strengthened copper alloy material is more than twice as expensive as a conventional chrome copper alloy.

Accordingly, it is seen that there is a need for a bimetal electrode having a dispersion strengthened copper tip and a shank portion formed of a less expensive, high conductivity copper which is sufficiently hard to withstand the stress of a resistance welding operation.

It is an object of the present invention to provide a work hardened, bimetal resistance welding electrode having a shank portion of

inexpensive high conductivity copper and a tip portion of dispersion strengthened copper alloy. Another object is to provide a method of making such an electrode.

From one aspect, the invention consists in a welding electrode for resistance welding comprising an extrusion hardened hollow shank of high conductivity copper having a central cavity into which cooling liquid may be supplied, a dispersion strengthened tip of a copper and aluminum oxide alloy, and a brazed connection between the tip and the shank, said brazed connection being located adjacent the central cavity, whereby cooling liquid supplied to said cavity cools said shank and said brazed connection during resistance welding.

From another aspect, the invention consists in a method of making a resistance welding electrode, comprising the steps of forming a first billet of high conductivity copper, forming a second billet of dispersion strengthened copper alloy, brazing said billets together at a temperature which does not anneal the dispersion strengthened copper alloy to form a bimetal extrusion blank, and extruding the blank to form a welding electrode having an extrusion hardened hollow shank of the high conductivity copper brazed to a dispersion strengthened copper alloy tip, the brazed connection being located adjacent the cavity in the hollow shank.

As the brazed connection between the tip and the shank is produced prior to extruding the shank, the shank is ultimately extrusion hardened, even if annealed by the brazing process.

In one preferred embodiment, the bimetal resistance welding electrode is formed by cutting a first rod of the desired quantity of the high conductivity copper for the shank of the electrode and upsetting this first rod to form the first billet as a solid cylindrical billet of extrusion diameter having a positive or male locator protrusion centrally positioned on one end thereof. A second rod of the desired quantity of dispersion strengthened copper alloy material for the electrode tip is cut and upset to form the second billet as a solid cylindrical billet of extrusion diameter which has a negative or female locator recess centrally positioned in one end thereof. The first and second cylindrical billets are placed together with brazing compound therebetween such that the protrusion and the recess mate. The billets and brazing compound are then heated and the billets are brazed together into a single extrusion blank. The extrusion blank is then back extruded such that the full hard bimetal electrode is formed.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in

which:-

*Figure 1* shows a rod of high conductivity copper;

*Figure 2* shows the copper rod of *Figure 1* after upsetting to form a cylindrical billet;

*Figure 3* shows a rod of dispersion strengthened copper material;

*Figure 4* shows a billet formed from the rod of *Figure 3*;

*Figure 5* shows a bimetal cylinder formed by brazing together the billets of *Figure 2* and *4*;

*Figure 6* is a sectional view taken generally along line 6--6 in *Figure 5*;

*Figure 7* is a view showing the cylinder of *Figure 6* after extrusion;

*Figure 8* shows the final electrode after machining; and

*Figures 9 and 10* illustrate the back extrusion process by which the electrode is formed.

Reference is now made to *Figures 1-8* in which the various steps for forming the bimetal resistance welding electrode are illustrated. As shown in *Figure 1*, a rod or wire 15 of high conductivity copper is cut producing a piece of appropriate volume for the shank portion of the electrode. Rod 15 is then upset to form the solid cylindrical billet 20 of predetermined diameter, as illustrated in *Figure 2*. Cylindrical billet 20 has a positive locator protrusion 25 which is centrally positioned on end 30.

A rod or wire 35 of the desired quantity of dispersion strengthened copper alloy material is cut, as shown in *Figure 3*. The copper alloy may advantageously be of the type disclosed in U.S. Patent No. 3,779,714, issued December 18, 1973, to Nadkarni et al, and marketed by the Glidden-Durkee Division of SCM Corp., Baltimore, Maryland, 21226 as GLID COPPER. This alloy resists annealing at elevated temperatures and is an extremely good electrical conductor, as well as being very hard. These properties are accentuated by cold working of the alloy. The upsetting process by which the billet 40 of *Figure 4* is formed thus has the effect of working the metal to produce an extremely hard billet. Preferably, the cold working should be sufficient to increase the cross sectional area by at least 50%. Billet 40 is of the same diameter as billet 20 and has a negative locator recess 45 positioned centrally in end 50.

As shown in *Figures 5 and 6*, billets 20 and 40 are placed together with a brazing compound therebetween such that the protrusion 25 and the recess 45 will mate. The billets are heated to approximately 1350° Fahrenheit and brazed to form extrusion blank 60. Since the dispersion strengthened copper resists annealing up to approximately 1700°F, the billet 40 remains full hard; the high conductivity copper in billet 20 will be

annealed, however, as the brazing compound melts. Extrusion blank 60 is then back extruded to form the electrode of *Figure 7* having a full hard, hollow extruded shank 65 of high conductivity copper and a dispersion strengthened copper tip 70 with a brazed connection 75 between the two. A central cavity 80, defined by shank 65, may be supplied with a cooling liquid during the resistance welding process. As seen in *Figure 8*, a locking taper portion 85 may be machined onto shank 65 by any one of a number of processes including grinding and cutting. The tip portion 70 may also have slight portions removed by machining, such as at 90, to produce the final desired tip shape.

*Figures 9 and 10* are illustrative of the back extrusion process by which the electrode of the present invention may be formed. The extrusion blank 60, comprising billets 20 and 40 which have been brazed together, is placed in an extrusion die 95. The blank 60 is supported by a knock-out pin 100 during the extrusion process. A carbide tapered insert 103 is provided to minimize wear. An extrusion punch 105 is pressed into die 95, causing the billet 20 of high conductivity copper to extrude upward above the die, as shown in *Figure 10*. This extrusion process forms the cavity 80, and, at the same time, extrusion or work hardens the shank portion 65 of the electrode. As will be noted in *Figure 10*, the working of the dispersion strengthened copper tip portion 70 is not substantial during the extrusion process. Since, however, the tip portion was not softened by annealing during the brazing process, working of the tip portion is not needed to reharden it. It is important, however, that the brazed connection 75 be adjacent the cavity 80 in the final electrode such that all of the high conductivity copper will be cooled by the fluid in cavity 80. If all of the shank 65 of high conductivity copper were not cooled, the shank would anneal and soften.

#### WHAT WE CLAIM IS:-

1. A welding electrode for resistance welding comprising an extrusion hardened hollow shank of high conductivity copper having a central cavity into which cooling liquid may be supplied, a dispersion strengthened tip of a copper and aluminum oxide alloy, and a brazed connection between the tip and the shank, said brazed connection being located adjacent the central cavity, whereby cooling liquid supplied to said cavity cools said shank and said brazed connection during resistance welding.

2. A welding electrode as claimed in claim 1, in which the central cavity extends into the dispersion strengthened tip, and in which the brazed connection surrounds said central cavity.

3. A welding electrode as claimed in claim 1 or 2, in which the brazed connection comprises a ring-shaped braze connection between the shank and the tip.

5 4. A welding electrode as claimed in claim 1, 2 or 3, in which the extrusion hardened hollow shank is fully extrusion hardened.

10 5. A welding electrode for resistance welding, constructed substantially as hereinbefore described with reference to the accompanying drawings.

15 6. A method of making a resistance welding electrode, comprising the steps of forming a first billet of high conductivity copper, forming a second billet of dispersion strengthened copper alloy, brazing said bil-  
20 lets together at a temperature which does not anneal the dispersion strengthened copper alloy to form a bimetal extrusion blank, and extruding the blank to form a welding  
25 electrode having an extrusion hardened hollow shank of the high conductivity copper brazed to a dispersion strengthened copper alloy tip, the brazed connection being located adjacent the cavity in the hollow shank.

30 7. A method as claimed in claim 6, including the steps of cutting a first rod of the desired quantity of the high conductivity copper for the shank of the electrode, upsetting said first rod to form the first billet as a first solid cylindrical billet of extrusion  
35 diameter having a positive locator protrusion which is centrally positioned on one

end thereof, cutting a second rod of the desired quantity of dispersion strengthened copper alloy for the electrode tip, upsetting said second rod to form the second billet as a second solid cylindrical billet of extrusion  
40 diameter having a negative locator recess centrally positioned in one end thereof, placing together the first and second solid cylindrical billets with brazing compound therebetween such that said protrusion and  
45 said recess mate, and heating the first and second solid billets and the brazing compound such that the billets are brazed together to form the extrusion blank.

8. A method as claimed in claim 6 or 7, including the further steps of forming a  
50 locking taper on the shank and forming the tip portion of the electrode into a desired shape.

9. A method as claimed in claim 6, 7 or 8, in which the step of forming a second  
55 billet of dispersion strengthened copper alloy includes the step of cold working a rod of dispersion strengthened copper alloy such that its cross sectional area is increased at  
60 least 50%.

10. A method of making a resistance welding electrode, substantially as hereinbefore described with reference to the accom-  
65 panying drawings.

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FIG-1

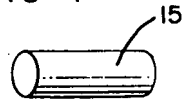


FIG-2

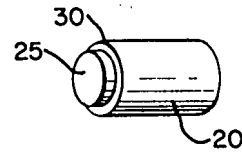


FIG-3



FIG-4

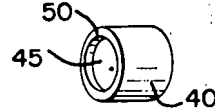


FIG-5

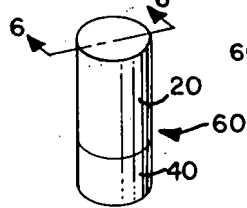


FIG-6

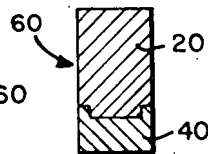


FIG-7

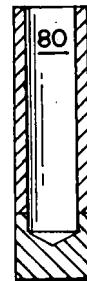


FIG-8

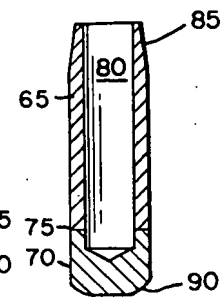


FIG-9

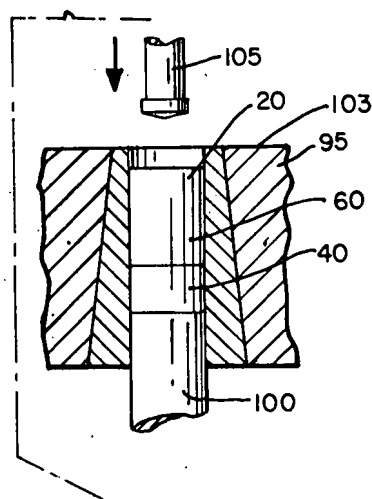


FIG-10

